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ABSTRACT

Provided is a study guide for an introductory minicourse to the principles of chemical reactions. This written text is designed to accompany a series of audio tapes and 35mm slides which the student studies at his own pace. The course presents chemical kinetics, reaction mechanisms, reaction rates, and equilibrium. (SL)

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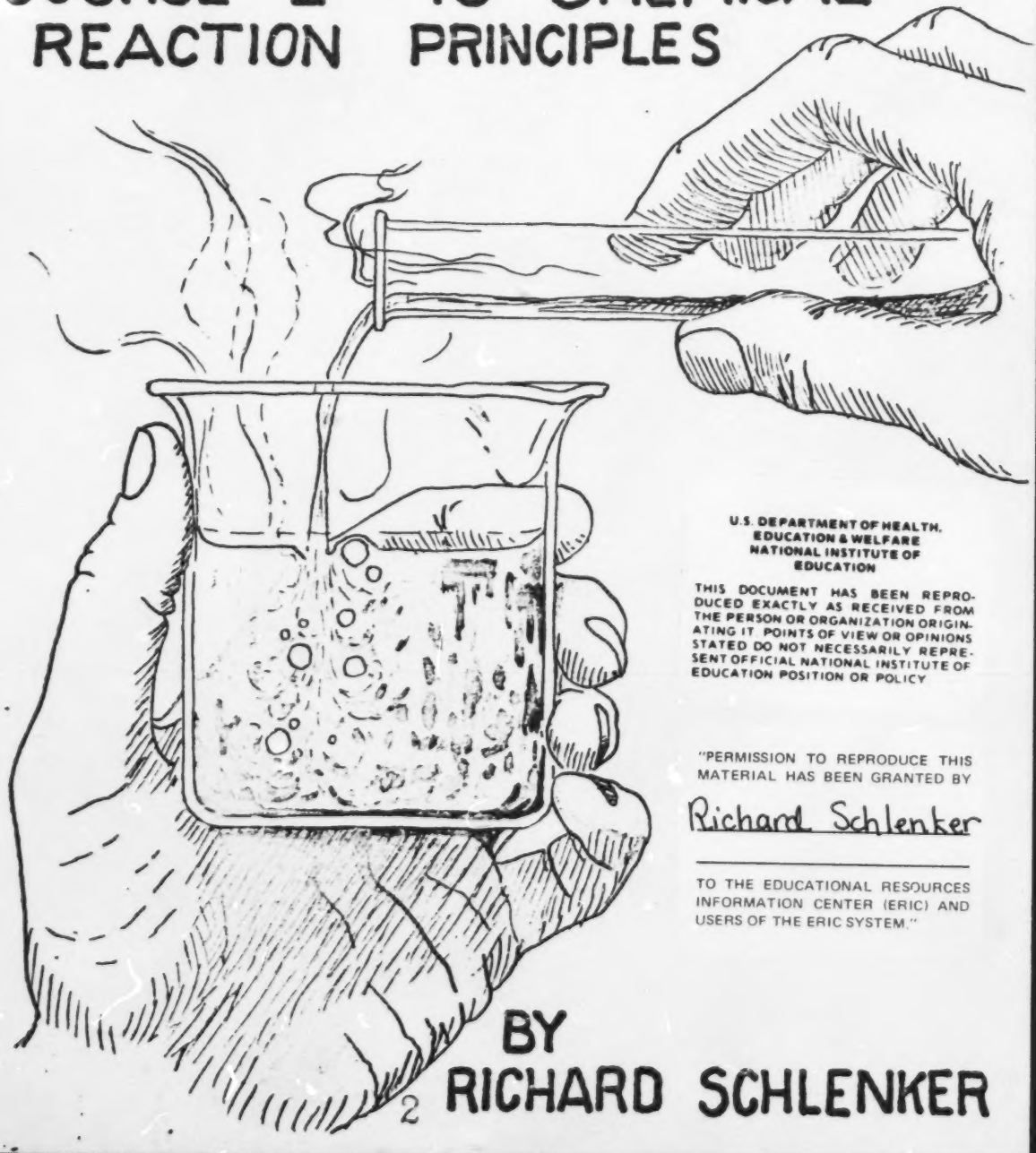
CH1 INTRODUCTION TO CHEMISTRY

STUDY GUIDE

TO

MINICOURSE I - 13 CHEMICAL REACTION PRINCIPLES

ED155011



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BY
RICHARD SCHLENKER

SE 024 257

WHAT IS ACTIVATION ENERGY?

WHAT MAKES REACTIONS OCCUR?

WHY DO SOME REACTIONS TAKE MORE TIME THAN OTHERS?

HOW DO OPEN AND CLOSED CHEMICAL SYSTEMS COMPARE?

WHAT IS A REACTION MECHANISM AND HOW DOES IT RELATE TO REACTION RATE?

WHAT ARE THE EFFECTS OF HEAT AND PRESSURE UPON CHEMICAL REACTIONS?

WHAT IS THE MEANING OF EQUILIBRIUM?

Summary

This introductory minicourse attempts to answer some of the questions posed on the preceeding page. These questions are answered by introducing the student to the principles of chemical reactions. In accomplishing these tasks, the student may use the audio tape I-13, Chemical Reaction Principles; Brown, T.L., & LeMay, H.E. Chemistry The Central Science. Englewood Cliffs, New Jersey 07632: Prentice Hall 1977; Hill, J.C. Students Guide to Brown and LeMay Chemistry the Central Science; Brown, T.L., & LeMay, H.E. Solutions to Exercises in Chemistry the Central Science; Nelson, J.H., & Kemp, K.C. Laboratory Exercises for Brown and LeMay Chemistry the Central Science; various laboratory equipment; the 35mm slide carousels part I, and Part II Chemical Reaction Principles by Denoyer-Geppert Audio-Visuals, Times Mirror 1971. In addition to these materials, the student is encouraged to use any additional materials which may help to clarify the subject matter.

Rationale

Life as we know it is a vast series of chemical reactions. Each day we consume a great quantity of substances. These substances are acted upon, metabolized by the body, circulated, and used. Each action or reaction we make requires a complex series of biochemical reactions. The fuel we burn in our homes, cars, aircraft, and ships is oxidized with the resultant production of energy. Dead materials go through a process called biodegradation during which the various elements are returned to the environment. Fossil fuels are changed chemically to produce plastics, and asphalts. Iron ore is changed chemically to produce the many grades of steel which are an integral part of everyday life, and so it goes. If we are truly to understand life as we know it, we must understand the principles behind chemical reactions.

The type of study you will do in learning about chemical reactions allows you to proceed more or less independently. The procedures you will follow in this study are quite different from the conventional lecture type instruction with which you are perhaps most familiar. Therefore, it is important that you understand the types of activities that are designed to assist you in your study. Now secure audio tape I-13 and listen to side 1.

Prerequisites

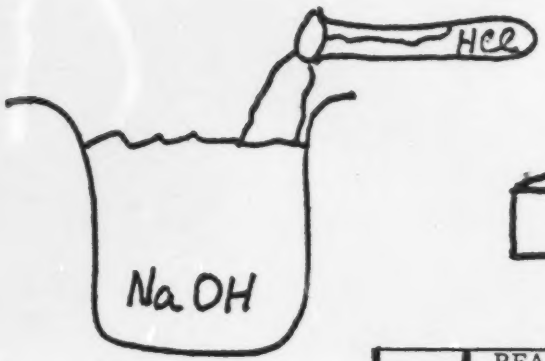
There are no prerequisites for this minicourse. However, students taking this minicourse should be familiar with the materials contained in the following minicourses: I-2, Atoms, Molecules and Ions; I-3, Conservation of Mass; I-4, Energy Relationships in Chemical Systems; I-6, The Electronic Structures of Atoms; I-8, Chemical Bonding; I-11, Liquids, Solids and Intermolecular Forces; and I-12, Solutions.

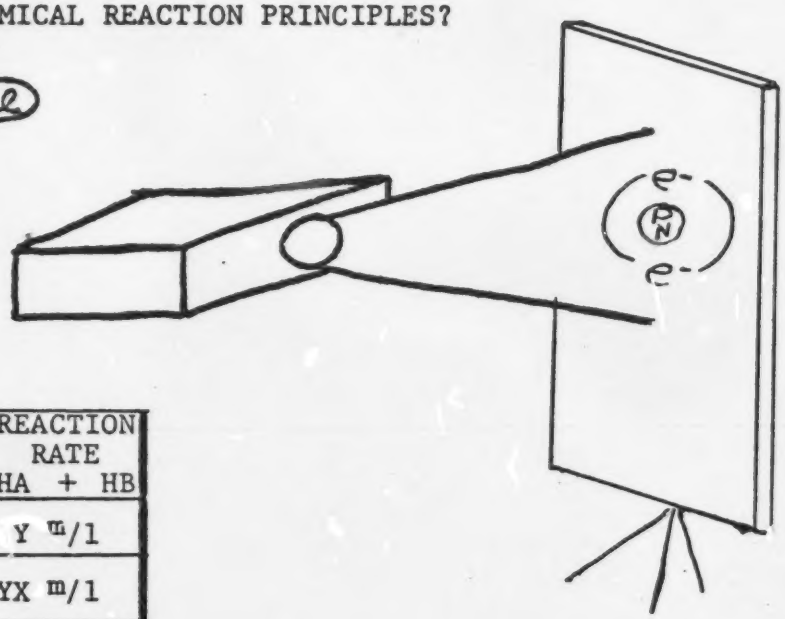
Objectives

Upon completion of this minicourse you will be able to:

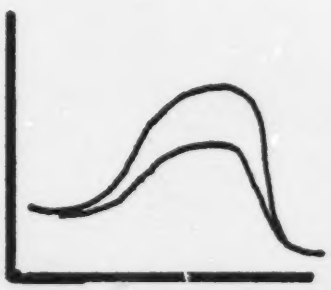
1. Define chemical kinetics in operational terms (ascertain reaction rates from empirical data).
2. Relate the concept of reaction mechanisms to overall chemical reactions.
3. Write a brief essay describing the relationship between collision theory and chemical reactions.
4. Interpret activation energy graphs for reactions in which catalysts are and are not present, and which are either exothermic or endothermic.
5. Define and describe the meaning of chemical equilibrium and apply the concept to actual situations.
6. State and explain the factors affecting chemical reaction rates.
7. Explain the meaning of reversible reactions and apply the concept to actual situations.
8. Describe the difference between open and closed chemical systems.
9. Compute first order reaction rates.

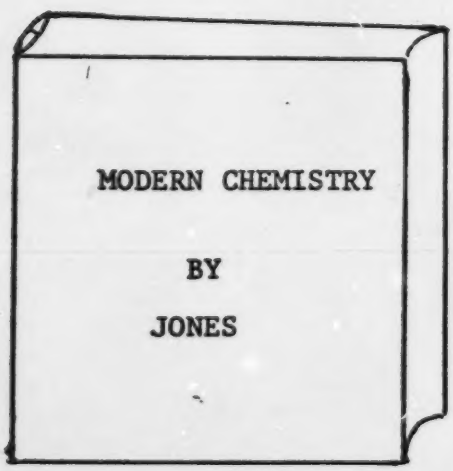
I. HOW CAN YOU STUDY CHEMICAL REACTION PRINCIPLES?





TEMP °C	REACTION RATE HA + HB
0°	Y $^{m}/1$
20°	YX $^{m}/1$
50°	$2X^{2}Y$ $^{m}/1$
100°	XYZ $^{m}/1$



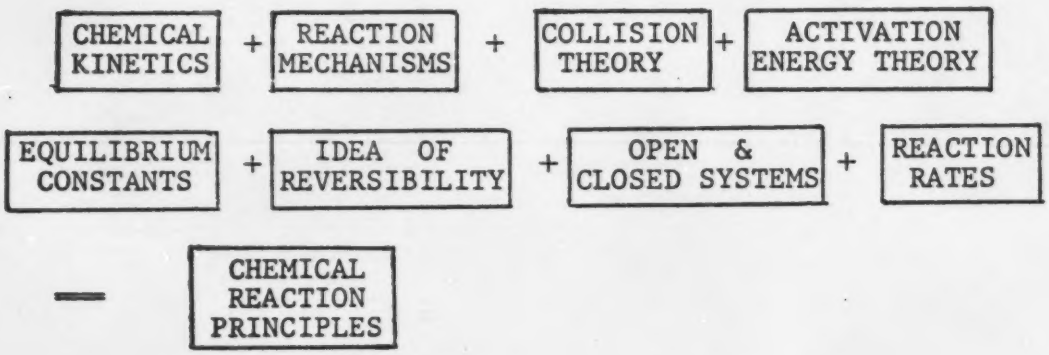


$2N_2O_5$ --- $4NO_2$ + O_2

RATE = ?

II. HOW IS THE CONTENT ARRANGED IN CHEMICAL REACTION PRINCIPLES?

A. Chemical Reaction Principles. Chemical Reaction Principles is a complete unit of subject matter, a set of objectives, and an end of course examination. The objectives should be mastered completely by the student. The end of course examination is based upon the course objectives.



B. Learning Activities. The learning activities are the the things you will do to help you achieve the objectives of the minicourse. List at least five activities.

1. _____
2. _____
3. _____
4. _____
5. _____

C. Help. An instructor will be present at all times to assist you when you do not understand either the subject matter or the instructions for carrying out part of the course. The learning activities have been sequenced to provide a coordinated approach to achieving the objectives. You will receive some of your instructions by audio tape while others are printed in the minicourse booklet (study guide).

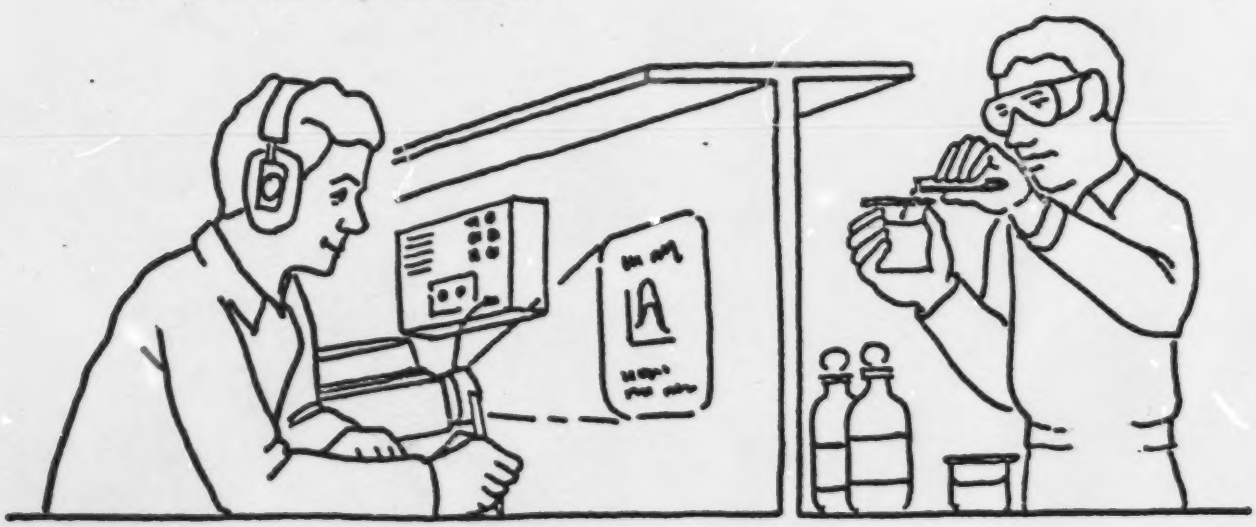
D. Grades. The goals of this minicourse are, (1) to help you learn the concepts involved with chemical reaction principles, (2) to help you apply chemical reaction principles to new situations and, (3) to help you demonstrate your scholarly understanding of chemical reaction concepts.

1. The basic content of this minicourse is outlined by the written objectives in the objectives above. The end of minicourse examination will be based upon those objectives, that is, you will be tested to see if you have met the objectives. If so, you should be able to demonstrate those competencies.

2. Your grade will be determined on a pass/fail basis. The level of minimum competency is 90%. If you obtain a grade of 90% on the examination it will be assumed that you have met the objectives and so, have successfully completed the minicourse. If, on the other hand, you fail to attain the 90% competency level it will be assumed that you have not yet met the minicourse objectives and you will be required to take another examination over the same material.

III. THE LEARNING ACTIVITIES

It is now time to begin a sequence of learning activities. Return to the audio tape and listen to the section which follows the introductory comments.



A. Exercise 1. Locate laboratory exercise number 5, "Chemical Reactions," in Laboratory Experiments for Brown and LeMay Chemistry the Central Science. Read through the activity carefully. When you understand the procedures, conduct the activity, answer the review questions, and submit the report sheet for evaluation.

1. Now that you have completed the activity, list some observations which might be characteristic of chemical reactions other than those which you have performed.

_____

_____

_____

_____

_____

Some of the characteristics you should be aware of as a result of conducting Exercise 1 and perhaps have listed in the spaces provided for that purpose may be found on the audio tape. Return now to the tape and compare your responses with those provided by your instructor.

B. Questions related to text section 13.1, and carousel number 1 slides 1 through 6.

1. Define KINEMATICS_____

_____

2. When two reagents are placed in the same container, the two species must collide for a third species to be formed. What is the relationship between the way the reactants collide and their success in forming a third species?

_____

_____

3. What is the relationship between time, concentrations of reactants, and products, and how might they be used to ascertain the rate at which the reaction occurs?

_____

_____

_____

4. What has the slope of a line at a point of tangency to the reaction rate curve to do with reaction rate?

5. How does initial reaction rate compare with final reaction rate?

Compare your answers to these questions with the information provided on the slides and in the text. Once you are satisfied that you understand the relationships between time, reaction rate and concentration, continue on.

C. Read, "Reaction Rates: General Considerations," "Reaction Rates: First-Order," "Reaction Rates: Higher-Order Reactions, and "Reaction Mechanisms" in the OVERVIEW OF THE CHAPTER section of Chapter 13 in Students Guide to Brown and LeMay. Once you have familiarized yourself with the individual objectives for each of the sections, listen to the next section of the audio tape.

1. Exercise 2. Locate laboratory exercise number 22, "Rates of Chemical Reactions I: A Clock Reaction" in your laboratory manual, and read it thoroughly. When you are familiar with the procedures that must be followed to conduct the experiment, you may collect the necessary equipment and conduct the activity. Once you have completed the activity submit the report sheet to your instructor for evaluation. Then listen to the next section of the audio tape.

D. Questions related to text sections 13.2, 13.3, 13.4, 13.6 and carousel number slides 7 through 19.

1. What is the relationship between an activated complex and a chemical reaction?

2. Hypothesize the relationship between an activated complex and a reaction mechanism.

3. What factors determine the rate at which chemical reactions occur?

4. If species A and B are to be mixed to produce product C, what is the relationship between collision probability and the change in concentration of either species A or B?

5. Is there a relationship between collision probability and reaction rate?

6. It is said that the Law of Mass Action is related to collision frequency and reagent concentration. Explain the meaning of this statement.

Listen to the next section of the audio tape.

E. Factors Affecting Reaction Rates. View slides 20 through 36, and 38 through 61 of carousel number 1, and 1 through 49 of carousel 2, and then study sections 13.5 and 13.7 in your text. Once you have completed this task, see how many factors you can list which affect reaction rates.

1.
2.
3.
4.
5.
6.
7.
8.

Some of the factors that you might have listed are given to you in PART III, E of the audio tape. Listen to them now.

How does each of these factors affect the rate of reaction?

1.
2.
3.
4.

5. _____

_____

6. _____

_____

7. _____

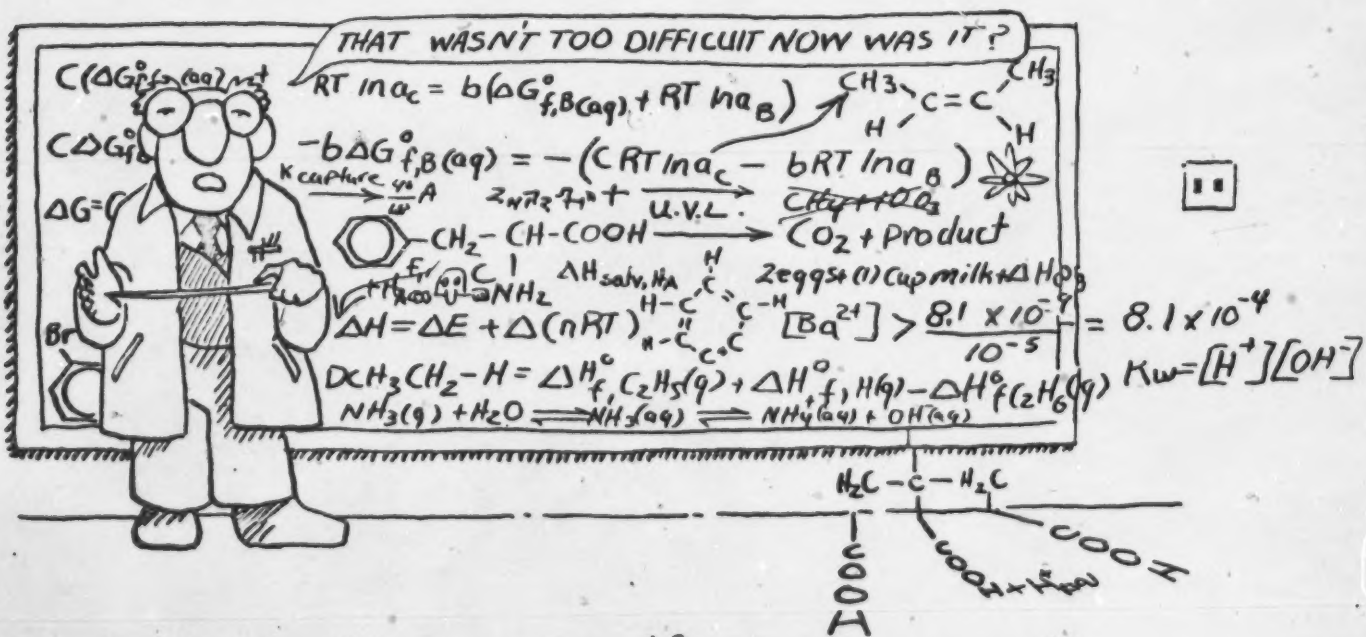
_____

8. _____

_____

You may check your answers by comparing them with slides number 20 through 36, and 38 through 61 of carousel 1, and slides number 1 through 49 of carousel 2, as well as sections 13.1, 13.5, and 13.7 of your text. If you are satisfied with the answers your intuition has provided, read exercises 11, 12, 13, 17, 18, and 19 in the "Topic Summaries and Exercises" section of the Students Guide to Brown and LeMay. Listen to the next section of the audio tape.

F. Review. You have completed your study of Reaction Rate Principles and it is now time for review. Turn to the "Key Terms" section of the Students Guide to Brown and LeMay and see if you can answer the questions in that section. Then compare your answers with those immediately following the section. If you feel that additional review is needed, try the self study quiz in the same section of the publication. When you have completed these activities, return to the audio tape.


THAT WASN'T TOO DIFFICULT NOW WAS IT?
$RT\ln a_c = b(\Delta G^\circ_{f,B(aq)} + RT\ln a_B)$
$-b\Delta G^\circ_{f,B(aq)} = -(cRT\ln a_c - bRT\ln a_B)$
$\Delta H = \Delta E + \Delta(nRT)$
$CH_3CH_2-H = \Delta H^\circ_f, C_2H_5(g) + \Delta H^\circ_{f,H(g)} - \Delta H^\circ_f(C_2H_6(g))$
$NH_3(g) + H_2O \rightleftharpoons NH_3(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
$K_w = [H^+][OH^-]$
$= 8.1 \times 10^{-4}$

REFERENCES

1. Brown, T. L., & LeMay, H. E. Chemistry the central science. Englewood Cliffs, New Jersey 07632: Prentice-Hall, Inc., 1977.

2. Brown, T. L. & LeMay, H. E. Solutions to exercises in chemistry the central science. Englewood Cliffs, New Jersey 07632: Prentice-Hall, Inc., 1977.

3. Denoyer-Geppert Audio-Visuals Chemical reaction principles. Parts I & II. Denoyer-Grepert Audio-Visuals, 1971.

4. Hill, J. C. Students guide to brown and lemay chemistry the central science. Englewood Cliffs, New Jersey 07632: Prentice-Hall, Inc., 1977.

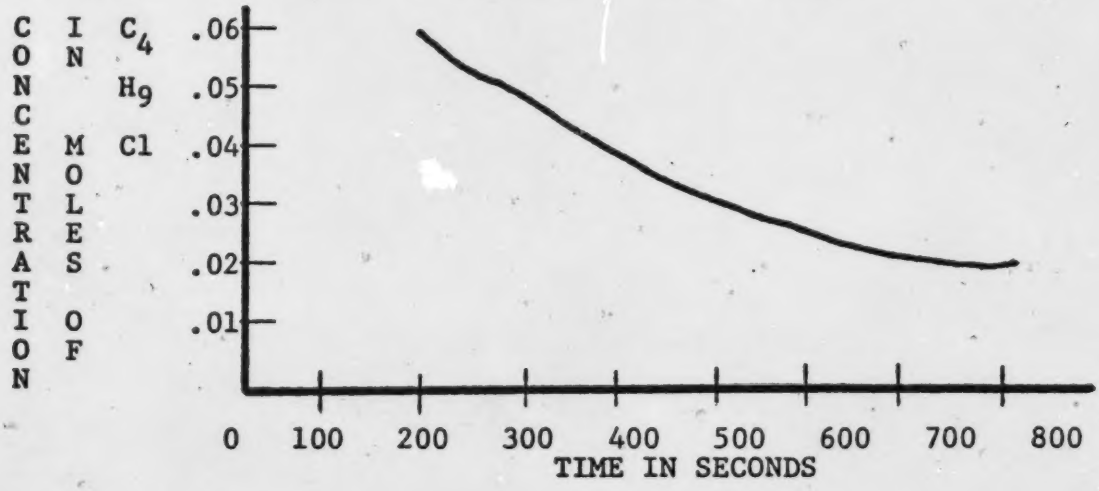
5. Nelson, J. J. & Kemp, K. C. Laboratory experiments for brown and lemay chemistry the central science. Englewood Cliffs, New Jersey 07632: Prentice-Hall, Inc. 1977.

MINICOURSE I-13 EXAMINATION I

1. Using the graph provided below, determine the reaction rate for

$$C_4H_9Cl + H_2O \rightarrow C_4H_9OH + HCl$$

during the time interval between 350 and 450 seconds.



2. Describe the relationship between the collision theory of chemical reactions and the rate at which a reaction occurs.

3. Under conditions of STP which reaction would you expect to reach equilibrium first? Explain your reasoning.

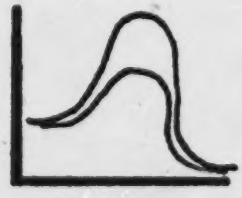
(1) A + B $\rightleftharpoons$ AB
1 mole 1 mole

(2) A + B $\rightleftharpoons$ AB
2 moles 1 mole

(3) A + B $\rightleftharpoons$ AB
1 mole 2 moles

(4) A + B $\rightleftharpoons$ AAB
2 moles 2 moles

4. Interpret the following graphs in terms of activation energy and explain which reaction reaches completion first and why.



5. In terms of reaction mechanisms, discuss the following groups of equations. In your discussion, explain which mechanism is most likely and why.

OVERALL REACTION: $2H_2(g) + 2NO(g) \longrightarrow N_2(g) + 2H_2O(g)$

(1) $H_2(g) + NO(g) + NO(g) \longrightarrow$

$H_2(g) + N_2O(g) \longrightarrow N_2(g) + H_2O(g)$

(2) $2NO(g) \longrightarrow N_2O_2(g)$

$N_2O_2(g) + H_2(g) \longrightarrow N_2O(g) + H_2O(g)$

$N_2O(g) + H_2(g) \longrightarrow N_2(g) + H_2O(g)$

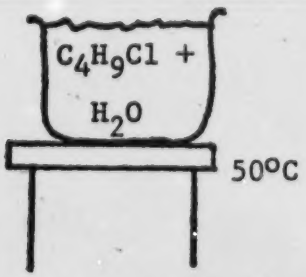
6. Two reagents when mixed are known to form a third species. Several moments after the reagents have been mixed, a sample is analyzed and the concentration of the third species is found to be .1 moles/liter. The process is repeated 5 minutes later with the same results. What can be said of the reaction?

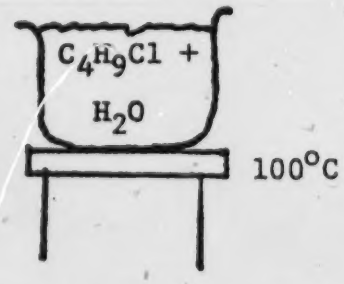
7. In question number six, a sample was analyzed and the quantities of all three species ascertained. Then a quantity of the species which was formed by the original reagents was added and another sample was analyzed. The analysis showed that the concentrations of the original reagents had increased. What can be said of this reaction?

8. The following reaction is known to occur:

$$C_4H_9Cl + H_2O \longrightarrow C_4H_9OH + HCl$$

Evaluate the following situation:





9. Describe and give examples of closed and open chemical systems.

TAPESCRIPT FOR MINICOURSE I - 13, CHEMICAL REACTION PRINCIPLES

MUSIC

Introductory Comments.

This is Minicourse I - 13, Chemical Reaction Principles. In the course of your study of Chemical Reaction Principles you will pursue several activities designed to aid your conceptualization of the topic. You will view slides, read textual material, conduct laboratory experiments, and solve problems. Specifically, you will study selected sections in Chemistry the Central Science, conduct experiments numbers 5 (Chemical Reactions), 22 (Rates of Chemical Reactions I: A Clock Reaction) and 23 (Rates of Chemical Reactions II: Chromium - EDTA) in Laboratory Experiments for Brown and LeMay Chemistry the Central Science, view the slides mentioned in your minicourse booklet, and solve selected problems from your text. Return now to the point in your minicourse booklet where you last stopped and read on.

PAUSE

Part III, The Learning Activities

You have reached the point in the minicourse which brings you to involvement in the learning activities. At this point, you should have an overview of the course as well as a feeling for some of the reasons why it is important to study the principles behind chemical reactions. You should also be aware of competencies you will be expected to demonstrate as a result of your study, how you will develop your understanding to the point of competency, and

how you will demonstrate that you have reached the required competency level. If you have additional questions about these matters, you should consult one of the chemistry instructors. Return now to the point in your minicourse booklet where you last stopped, and read on.

PAUSE

Part III, A.1. Some Ideas You Should Be Aware of As a Result of Completing Exercise 1.

As a result of your study of Exercise 1, you should realize that, (1) some reactions require the input of heat before they can occur, (2) some reactions produce heat, (3) the addition of a reagent to a solution sometimes produces a precipitate, (4) gases are evolved from some chemical reactions, (5) odor may be indicative of a species produced by a reaction occurring when two or more reagents are added, (6) the amount of heat added seems to affect the rate at which a reaction proceeds, and so on.

With these thoughts in mind, turn to Chapter 13 of Students Guide to Brown and LeMay Chemistry the Central Science and read in the overview of the chapter section, "Reaction Rates, General Considerations." Now turn to your text, Chemistry the Central Science, and study section 13.1. Study that section now.

PAUSE

At this point, view slides numbers 1 through 6 of Chemical Reaction Principles, Carousel 1.

PAUSE

Return to your study guide and answer the questions in PART III B, without referring to either the text or the slides.

PAUSE

Part III C.

As a result of studying sections 13.1 through 13.4, and 13.6 in Brown and LeMay as well as slides numbers 1 through 20 you should be able to relate reaction rates to time and concentrations of reagents and products, articulate the meaning of rate constants, ascertain the values of rate constants, apply the concept of half life to rate constants, explain the meaning of reaction mechanisms, and relate reaction mechanisms to reaction rates and rate constants.

Now study sections 13.2, 13.3, 13.4, and 13.6 in the text. After you have read these sections, consult your study guide for further instructions.

PAUSE

Part III, C.1 Written Exercises Part I.

It is now time to test your facility with the material you have studied to this point. This can be accomplished by solving the odd numbered exercises at the end of Chapter 13 in your text. Specifically, you should solve exercises numbers 13.1, 13.3, 13.5, 13.7, 13.9, 13.11, 13.13, 13,19, 13.21, 13.23, 13.25. Stop the tape and solve the problems and once finished, return and listen to the next section of the audio tape.

PAUSE

Compare your solutions to the exercises with those in Chapter 13, "Rates of Chemical Reactions" of Solutions to Exercises in

Chemistry the Central Science.

If differences exist consult the relevant sections in the text and review the related slides. In the event that a dilemma still exists, consult one of the chemistry instructors. Once you are satisfied, see if you are able to answer the questions in your study guide.

PAUSE

Part III, D. 6, Written Exercises Part II.

Turn to the Student Guide to Brown and LeMay, Chapter 13, and study exercises 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14, 15, and 16 in the "Topic Summaries and Exercises" section. Upon completion of your study of this section, see Part III E in the study guide.

PAUSE

Part III, E.1.

Many factors affect the rate of a chemical reaction. Some of those factors are (1) temperature, (2) pressure, (3) energy of the reactants, (4) concentration of the reactants, (5) frequency of collision between particles, (6) proper orientation of reactant particles, (7) activation energe of the reaction, (8) the existence of a catalysis. Glance briefly at slide number 36 and then return to your study guide.

PAUSE

Part III, E.2.

Problems dealing with the effects of parameters such as temperature and catalysis upon reaction mechanisms. At the end of Chapter 13 in the text, do exercises 13.15, 13.17, 13.19, 13.21, 13.23, and 13.25. When you have finished with

these exercises, consult Chapter 13 in Solutions to Exercises in Chemistry the Central Science. Pause now and accomplish these tasks. When you have finished, turn on the tape again.

PAUSE

Exercise 3.

Locate experiment 23, "Rates of Chemical Reactions II: Chromium-EDTA" in Laboratory Experiments for Brown and LeMay and read it thoroughly. When you are familiar with the various steps, collect the necessary chemicals and equipment, and conduct the experiment. Notice that the experiment is to be conducted by a team of six people. Following the completion of the exercise, submit the report sheet to your instructor for evaluation. Pause now and conduct the experiment, and then consult the next section of your study guide.

PAUSE

Part III, F. Review and Conclusions.

During your study of reaction rate principles you have considered the effects of concentration, temperature, pressure catalysis, energy of the reactants, orientation of the reacting particles, activation energy, and reaction mechanisms upon the rate at which reactions proceed. In addition, you have studied the computation of reaction rate constants, chemical equilibrium, and open and closed chemical systems. In the event that questions remain concerning some of the mathematical computations covered in this minicourse, ask your instructor for the supplemental set of overhead projections covering Reaction Rate Principles. They may be projected on the screen in the laboratory.

As the final activity, consult the behavioral objectives at the beginning of the study guide, and those in the text Chapter 13. Have you met each of these objectives? If you feel that you have, can you either write or verbalize a short statement indicating what it means to demonstrate some facility with each of these. If you can, you are ready to take an examination covering the minicourse materials. GOOD LUCK.

MUSIC